AMENDED CLAIMS

[Received by the International Bureau on 28 July 2004 (28.07.04): original claims 1-11 replaced by amended claims 1-9]

The present invention is applicable to a system that processes loadflow computation by means of the slack-start procedure, modified real and reactive power residues, and gain matrices derived from the Jacobean matrix. The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of controlling voltages and power flows in a power network, comprising the steps of:

   Obtaining on-line/simulated data of open/close status of switches and circuit breakers in the power network,

   obtaining on-line readings of real and reactive power assignments or settings at PQ-nodes, real power and voltage magnitude assignments or settings at PV-nodes and transformer turns ratios, which are the controlled variables/parameters,

   performing loadflow computation by a decoupled loadflow method employing successive (1θ, 1V) or simultaneous (1V, 1θ) iteration scheme to calculate values of the voltage angle and the voltage magnitudes at PQ-nodes, voltage angle and reactive power generation at PV-nodes, and tap positions of tap-changing transformers for said obtained online readings, or specified/set values, of controlled variables/parameters by using triangular factorization of super or alternatively transformed decoupled gain matrices that are defined independent of rotation angles applied to complex branch admittances by using admittance magnitudes with the same algebraic signs as those of the transformed susceptance values,

   initiating said loadflow computation with guess solution of the same voltage magnitude and angle as those of the slack or reference node referred to as slack start,

   evaluating the computed loadflow for any of the over loaded power network components and for under/over voltage at any of the network nodes,

correcting one or more controlled parameters and repeating the computing and evaluating steps until evaluating step finds no over loaded components and no under/over voltages in the power network, and

effecting a change in the power flowing through network components and voltage magnitudes and angles at the nodes of the power network by actually implementing the finally obtained values of controlled parameters after evaluating step finds a good power system or alternatively a power network without any overloaded components and under/over voltages, which finally obtained controlled parameters however are stored in case of simulation for acting upon fast in case the simulated event actually occurs,.

2. A method as defined in claim-1 wherein said decoupled loadflow computation, employing successive (1θ, 1V) iteration scheme, is characterized in:

using computation of variables representing quotients of transformed discrepancies from specified values of real power flowing in through PQ-nodes divided by squared voltage magnitude and quotients of discrepancies from specified values of real power flowing in through PV-nodes of the power network divided by a multiplication of squared voltage magnitude and a factor determined as the absolute value of the ratio of a diagonal element of susceptance matrix to a corresponding diagonal element of said super decoupled gain matrix derived from Jacobian matrix for real power residue divided by squared voltage magnitude or simply the voltage magnitude with respect to the voltage angle, and using the transformed reactive power discrepancies from the specified values divided by voltage magnitude on each of the PQ-nodes, and

restricting nodal transformation or alternatively rotation angle to maximum -48 degrees, which can be tuned for the best possible convergence for any given system, applied to complex power injection in computing transformed discrepancies from specified values of real and reactive power flowing in through each of PQ-nodes, and

using network shunt parameter b_p' that appears in diagonal elements of gain matrix [YV] as given in the following relations:

$$Y\theta_{pp} = \sum_{q>p} -Y\theta_{pq} \quad \text{and} \quad YV_{pp} = b_p' + \sum_{q>p} -YV_{pq} \quad (37)$$

$$b_p' = (QSH_p'/V_s^2) - b_p Cos\Phi_p \quad \text{or} \quad b_p' = 2QSH_p'/V_s^2 \quad (38)$$

$$QSH_p' = QSH_p Cos\Phi_p - PSH_p Sin\Phi_p \quad \text{-for PQ-nodes} \quad (26)$$

3. A method as defined in claim-1 wherein said decoupled loadflow computations, employing simultaneous (1V, 1θ) iteration scheme are characterized in that they involve only one time calculation of real and reactive power residues in an iteration along with modified real power residue calculation, depending on decoupled loadflow computation method used, either by:

$$RP_p = (\Delta P_p / V_p) - \sum_{q=1}^{m} G_{pq} \Delta V_q \quad \text{-for PQ-nodes \& PV-nodes} \quad (71)$$

or

$$RP_p = \{[\Delta P_p' + (G_{pp}'/B_{pp}')\Delta Q_p'] / V_p^2\} - (g_p' \Delta V_p) \quad \text{-for PQ-nodes} \quad (85)$$

4. A simple system for controlling generator and transformer voltages of the more elaborate system of security control or alternatively voltage and power flow control defined in claim-1 can be realized in an electrical power utility containing plurality of electromechanical rotating machines, transformers and electrical loads connected in a network, each machine having a reactive power characteristic and an excitation element which is controllable for adjusting the reactive power generated or absorbed by the machine, and some of the transformers each having a tap changing element which is controllable for adjusting turns ratio or alternatively terminal voltage of the transformer, said system comprising:

means defining one of the loadflow computation models characterized in claim-1, claim-2, and claim-3 for providing an indication of the quantity of reactive power to be supplied by generators including the reference generator node or alternatively the slack generator node, and for providing an indication of transformer tap positions or alternatively transformer turns ratios in dependence on the read online/specified/set controlled network variables/parameters,

machine control means connected to the said loadflow computation model means and to the excitation elements of the rotating machines for controlling the operation of the excitation elements of machines to produce or absorb the amount of reactive power indicated by said loadflow computation model means with respect to the set of read online/specified/set controlled network variables/parameters including physical limits of excitation elements,

transformer tap position control means connected to the said loadflow computation model means and to the tap changing elements of the controllable transformers for controlling the operation of the tap changing elements to adjust the turns ratios of transformers indicated by the said loadflow computation model means with respect to the set of read online/specified/set controlled network variables/parameters including limits of the tap-changing elements.

5. A system as defined in claim 4 wherein the power network includes a plurality of nodes each connected to at least one of: a reference generator; a rotating machine; and an electrical load; and the said loadflow computation model means receives representations of selected values of the real and reactive power flow from each machine and to each load, and the model is operative for producing calculated values for the reactive power quantity to be produced or absorbed by each machine.

6. A system as defined in claim 5 wherein the power network further has at least one transformer having an adjustable transformer turns ratio, and said means

defining a loadflow computation model is further operative for producing a calculated value of the transformer transformation/turns ratio.

7. A system as defined in claim 4 wherein said machine control means are connected to said excitation element of each machine for controlling the operation of the excitation element of each machine, and wherein said transformer turns ratio control means are connected to said transformer tap changing element of each transformer for controlling the operation of the tap changing element of each transformer.

8 A method for controlling generator and transformer voltages in an electrical power utility containing plurality of electromechanical rotating machines, transformers and electrical loads connected in a network, each machine having a reactive power characteristic and excitation element which is controllable for adjusting the reactive power generated or absorbed by the machine, and some of the transformers each having tap changing element which is controllable for adjusting turns ratio or alternatively terminal voltage of the transformer, said method comprising:

creating any of the said decoupled loadflow computation models of the network defined in claim-1, claim-2 and claim-3 for providing an indication of the transformer tap positions and the quantity of reactive power to be supplied by the generators in dependence on read online/specified/set controlled network variables/parameters,

controlling the operation of the excitation elements of machines to produce or absorb the amount of reactive power, and controlling tap changing elements of transformers to control voltages of the connected nodes by transformer turns ratio indicated by any of the said decoupled loadflow computation models defined in claim-1, claim-2 and claim-3 with respect to the read online/specified/set controlled variable/parameters.

9. A method as defined in claim 8 wherein said step of controlling is carried out to control the excitation element of each machine, and to control the tap-changing element of each controllable transformer.